Diploma Programme
Programme du diplôme
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Markscheme

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Environmental systems and societies

Standard level

Paper 2

19 pages

Subject details: Environmental systems and societies SLP2 Markscheme

Mark allocation

Candidates are required to answer:
- **ALL** questions in Section A **[25]** and **TWO** questions in Section B **[40]**.
- The maximum total = **[65]**.

1. Environmental systems and societies uses marking points and markbands to determine the achievement of candidates

When using marking points (<u>All of this paper except</u> Section B, part (c) questions):

i. A markscheme often has more marking points than the total allows. This is intentional
ii. Each marking point has a separate line and the end is shown by means of a semi-colon (;)
iii. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **<u>precise point</u>** where it becomes clear that the candidate deserves the mark. **<u>One tick to be shown for each mark awarded</u>**
iv. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

When using markbands (<u>Only</u> for Section B, part (c) questions):

i. Read the response and determine which band the response fits into
ii. Then re-read the response to determine where the response fits within the band
iii. Annotate the response to indicate your reasoning behind the awarding of the mark
Do not use ticks at this point
iv. Decide on a mark for the response
v. At the end of the response place the required number of ticks to enable RM Assessor to input the correct number of marks for the response.

2. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

3. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

4. Words that are <u>underlined</u> are essential for the mark.

5. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect).

6. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

7. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.

8. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

Section A

1. (a) Costa Rica has a crude birth rate (CBR) of 15.3 and a crude death rate (CDR) of 4.8.

(i) Identify the stage in which Costa Rica would be placed on the demographic transition model shown in **Figure 1**. **[1]**

stage 3;

(ii) Calculate the natural increase rate (NIR) for Costa Rica. **[1]**

NIR = 1.05;

Note: *As there is some disagreement in the literature, accept 10.5 (per thousand)*

(iii) Calculate the doubling time for Costa Rica. **[1]**

$$\text{doubling time (DT)} = \frac{70}{\text{NIR}}$$

DT = 66.67 years;

Note*: Accept 67 years, but do not credit unless units are given.*

(b) Outline **one** strength and **one** limitation of the demographic transition model. **[2]**

*Strength **[1 max]***
provides a theoretical basis for comparing other societies;
can be applied to a wide range of societies;
allows predictions to be made regarding transitions / population growth;
it is based on historical data;
indicates relationship between multiple factors;

*Weakness **[1 max]**:*
many assumptions are made to make the model / relationships are quite simplistic;
Eurocentric model might not apply to all countries;
does not take into account events such as migration/war/rapid spread of disease that may have limited impact on populations;

(c) Outline the socioeconomic factors that may cause a society to move from Stage 2 to Stage 3 on the demographic transition model. **[3]**

decreasing birth rate/ fertility/growth / smaller families due to:
- increased access to contraception/family planning/sex education;
- improved (access to) healthcare / reduced child mortality;
- improved education/emancipation of women;
- shift from agricultural society / less dependence on child labour

continued decreasing death rate due to:
- improved sanitation;
- improved (access to) healthcare/food provision;

Note*: Must link answer to decreasing birth rate and/or decreasing death rate to earn mark.*
*Award **[2] max** if candidate addresses only birth rate or only death rate.*

2. (a) (i) Identify **one** transfer and **one** transformation process shown in **Figure 2**. **[2]**

transfer:
advection/precipitation/snowmelt runoff/surface run off/infiltration/percolation/groundwater flow/plant uptake;

transformation:
evaporation/condensation/sublimation/snowmelt/transpiration;

***Note**: Only credit those flows identified in diagram*

(ii) Outline how urbanization might impact **two** of the storages in **Figure 2**. **[2 max]**

reduction in biomass storage due to deforestation;
reduction of groundwater storage due to impermeable surfaces/urban withdrawal;
increase in lake/river/ocean storage due to deforestation/increase of impermeable surfaces;
less snow due to urban heat island effects;
increased sediment/pollution in lakes/rivers/oceans/groundwater due to construction/industrialized activities;

***Note**: Credit can be given for any aspect of urbanisation (deforestation/heat island/impermeable surface etc) with a relevant impact on a named storage that is depicted in given diagram. Only credit impacts on storages not on flows.*

(b) Runoff from agricultural land can result in excess nutrients entering water bodies.

(i) Outline **one** indirect measure of organic pollution. **[3]**

Alternative 1:
*Named measure **[1 max]**:*
biochemical oxygen demand;

*Methodology **[2 max]**:*
measure the initial dissolved oxygen;
keep a sample in the dark for five days and measure DO again;
take the difference of the two measurements;

Alternative 2:
*Named measure **[1 max]**:*
biotic index/indicator species;

*Methodology **[2 max]**:*
sample the macroinvertebrates in the stream/lake;
through kick sampling/dragging feet along bottom;
identify species present;
identify indicator species/tolerance levels;

***Note**: Do not credit any direct measure of pollutant like total suspended matter/ turbidity etc*

(ii) State **one** management strategy that could control the release of agricultural runoff. **[1 max]**

plant a buffer zone;
reduce the use of inorganic fertilizers / replace their use with organic fertilisers;
do not apply fertilizers in the rainy season;
keep animals away from waterways;
treat livestock wastewater (to reduce phosphates and nitrates);
contour ploughing/terracing/agroforestry/drip irrigation (to avoid run off);

3. (a) Calculate the percentage of sea turtle species from **Figure 4** that are critically endangered. **[1]**

$\frac{2}{7} = 28.6\%$;

Note*: Accept 28.57 / 28.6 / 29.*

(b) State **two** factors that are used to determine the conservation status of a species. **[2 max]**

population size;
rate of pop increase/decrease;
degree of specialization;
distribution;
reproductive potential and behaviour;
geographic range;
habitat quality/fragmentation;
trophic level;
probability of extinction;

(c) Identify **two** strategies for fisheries management that could improve the conservation status of sea turtles. **[2 max]**

restrict use of fishing nets/long lines;
bycatch reduction strategies;
establish marine protected areas/exclusion zones / police/implement laws against poaching/overexploitation;
replace wild fisheries with aquaculture;
ensuring fishing nets/lines are not lost at sea / reduce ghost/abandoned/lost nets/lines / *OWTTE*;

(d) Discuss how solid domestic waste disposal options could be used to reduce the threats to marine organisms. **[4 max]**

***Note**: Award **[1]** for any of following arguments or counterarguments (…)*

Recycling can reduce plastics entering waterways;
...but is costly/depends on changing lifestyles;
Landfill can reduce wastes entering waterways;
...but can still lead to leaching of toxins into aquatic environments;
Incineration can reduce wastes entering aquatic environments;
...but may cause air pollution and deposition/acidification of marine environments;
Composting can reduce organic waste polluting waterways;
...but is only suitable for biodegradable waste;
Littering laws can reduce waste entering marine systems
…but need appropriate penalties/monitoring etc;

Conclusion
e.g. recycling is probably the most reliable protection of marine organisms against plastic waste;

***Note**: Award **[3] max** if neither counterarguments nor conclusion are presented I.e. response must include at least one or the other to fulfil the 'Discuss' command term.*

Section B

Part (c) questions in Section B are all to be assessed using the markbands on page 22 with the guidance given below for each question.

4. (a) Distinguish between **two** named biomes and the factors that cause their distribution. **[4 max]**

e.g. tundra vs tropical rainforest:

*Distinguishing features **[3 max]**:*
tundra has lower insolation / TRF has the highest insolation of all biomes;
TRF has constant insolation throughout the year / tundra has long, dark winters;
tundra has lower mean annual temperature / TRF has warmer temperatures;
tundra has 6–10 months of freezing temperatures / TRF has constant warm temperatures;
TRF has the largest annual precipitation compared to any biome / tundra precipitation is as low as in deserts;
TRF has almost constant precipitation throughout the year;
tundra precipitation mostly in form of snow / tundra has a characteristic layer of frozen ground below the surface/permafrost;
TRFs have the highest biodiversity of all biomes;

*Explanation of distribution: **[2 max]***
tundra found at the poles, while TRFs at the tropics (above and below the equator);
Hadley cell rises at the Equator causing huge precipitation (low pressure zone) / as warm air cools and its moisture condenses;
tundra is found in the low pressure area of polar cell / at a region where there is net loss of solar energy (causing freezing temperatures) / alpine tundra found on mountaintops, where temperatures are below 0 most time of the year due to high altitude;

***Notes:** Award **[3] max** for correctly indentified distinguishing features i.e. insolation / temperature / precipitation / permafrost / high biodiversity etc.*
*Award **[2] max** for explanation of distribution.*
*Award **[2] max** overall if no biomes are named.*

(b) Evaluate **one** method for measuring primary productivity in a named ecosystem. **[7 max]**

Alternative 1:

Method:

light and dark bottle for an aquatic ecosystem;
measure dissolved oxygen at start and end of experiment;
compare measurements in a transparent (with light) and opaque (without light) bottle containing sample of water from ecosystem;
net productivity is equivalent to change in dissolved oxygen in light bottle;
gross productivity is equivalent to change in dissolved oxygen in light bottle plus the loss of dissolved oxygen in the dark bottle (due to respiration);
measurements taken for a set period of time, *eg* one week;

Evaluation:

simple, easy to conduct method;
ethical method – samples can be returned to ecosystem;
difficult to isolate primary producers from consumers in ecosystem sample;
only collecting productivity for submerged subset of ecosystem;
measurements dependent upon temperature;
quality of measurements depends on precision of instruments;

Alternative 2:

Method:

three comparison plots, one covered in opaque plastic for terrestrial ecosystem;
measure dry biomass at start and end of experiment;
compare measurements from an open (with light) and covered (without light) plot in ecosystem;
net productivity is equivalent to change in biomass in open plot;
gross productivity is equivalent to change in biomass plus the loss of biomass in the covered plot (due to respiration);
measurements taken for a set period of time, *eg* one week;

Evaluation:

easy to isolate primary producers in ecosystem sample;
difficult to collect all biomass;
ethical problems as samples need to be killed to measure dry biomass;
measurements dependent upon temperature;
productivity easier to measure in simpler systems;
difficult to measure with larger producers/trees;

***Notes**: Award **[3] max** for description of method. Evaluation should address inherent strengths and weaknesses of method. Do not credit examples of poor execution eg inaccurate measurement/samples too small etc.*
*Award **[6] max** if ecosystem is not named.*
No credit can be given to responses that mistakenly address eg biodiversity rather than productivity.

(c) Discuss how human activities impact the flows and stores in the nitrogen cycle. **[9 max]**

*The following guide for using the markbands suggests certain features that may be offered in responses. The five headings coincide with the criteria given in each of the markbands (although "ESS terminology" has been conflated with "Understanding concepts"). This guide simply provides some **possible** inclusions and should not be seen as requisite or comprehensive. It outlines the kind of elements to look for when deciding on the appropriate markband and the specific mark within that band.*

Answers may include:

- **understanding concepts and terminology** of systems approach; flows and (biotic and/or abiotic) stores in nitrogen cycle; atmospheric content; farming practices (aquatic and terrestrial); soil; eutrophication; urbanization, deforestation; transportation; forest fires; use of fossil fuels;
- **breadth in addressing and linking** climate change; photochemical smog; secondary pollutant; acid deposition; scrubbers/catalytic converters; renewable vs. non-renewable energy sources; population growth; EVSs; sustainable development;
- **examples** of farming practices (aquatic and terrestrial) which affect nitrogen flows; eutrophication/pollution management strategies; specific human activities causing atmospheric pollution;
- **balanced analysis** discussing activities which increase nitrogen flows and stores, as well as decreasing or managing these flows and stores;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* probably the greatest human disturbance to steady state equilibrium in the nitrogen cycle is the increase of inorganic stores such as nitrogen oxides in the atmosphere and nitrates in aquatic systems.

Please see markbands on page 22.

5. (a) Outline how a positive feedback loop can impact an ecosystem. **[4 max]**

positive feedback loops (destabilizing) amplify changes in an ecosystem;
feedback refers to the return of part of the output from a system as input so as to affect succeeding outputs;
this drives the system towards a tipping point where a new equilibrium is adopted;
this new equilibrium may be an alternative stable state / involve collapse of original system;
eg increased global temperatures are melting permafrost, leading to the release of methane;
...which is a greenhouse gas and leads to further increases in global temperatures;

***Note**: Candidates may gain full credit by illustrating the principles of positive feedback by means of a diagram or well-developed example. Credit should be allowed for this.*

(b) Compare and contrast the impact of **two** named food production systems on climate change. **[7 max]**

named food production system with description; (*eg* Iowa corn production in mid-west USA is highly intensive, relying upon large machinery and inorganic nitrogen fertilizers)
named food production system with description; (*eg* rice-fish farming in China is a low-intensity system managed by human labour, with few chemical inputs)

use of machinery vs human labour, dependency on fossil fuels;
use of organic vs inorganic fertilizers, intensive energy needs of production of inorganic fertilizers/NO_x released from use of inorganic fertilizers;
animal vs plant production, animals require more land use due to position in food chain;
types of greenhouse gases produced, *eg* both rice and animal production produce methane;

eg case study: Rice-fish farming in Thailand [1] v cattle farming in US [1]. Both rice and cattle produce methane, a greenhouse gas [1]. Inorganic fertilisers used in cattle farming releasing nitrogen oxides into atmosphere [1]. Rice is fertilised naturally from fish faeces so has no direct impact on climate change [1]. Cattle farming involves use of heavy machinery / fossil fuels not used in rice fish farming [1]. Rice farming produces food at lower trophic level so absorbs carbon dioxide [1].

***Notes**: Award **[2] max** for description of food production systems.*
Other points of comparison or contrast may be acceptable but must be explicitly linked to climate change in order to gain credit.
*Award **[4] max** if only points of comparison or only points of contrast are addressed*
Credit can be given for any points of comparison or contrast with regard to impact on climate change/release of greenhouse gases.

(c) To what extent does the development of different societies impact their choice of mitigation and adaptation strategies for climate change? **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of development (may not just be economic); mitigation and adaptation strategies; climate change; NAPA, UNFCCC and IPCC; EIAs
- **breadth in addressing and linking** climate change; demographic transition model; geographical factors such as location/biome; socio-economic and political factors may be related to EVS;
- **examples** of mitigation and adaptation strategies in at least two contrasting countries;
- **balanced analysis** discussing range of factors influencing a society's choices;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* the combination of political system and economic development will be the primary determinant of the choice of mitigation and adaptation strategies, with countries such as USA preferring to invest in adaptation strategies involving hard infrastructure while less economically developed countries will heavily support the implementation of IPCC climate goals (mitigation) and education of the population to mitigate problems;

Please see markbands on page 22.

6. (a) Outline **two** factors that enable a human population to increase its local carrying capacity. **[4 max]**

range of resources used;
…means that a local human population can consume/exploit more resources available locally than any other species;
human ingenuity/substitution;
…means that humans are capable to find alternative resources when one is near depletion;
variations in lifestyle;
…means that people can be flexible in their mode of consumption of limited/dwindling resources;
importation of resources;
…means that a wealthy population can grow beyond the boundaries set by their local resources;
technological developments; (can be linked to all previous factors)
…allows humans to use available resources more efficiently / discover new resources / import resources from far away;

***Note**: Award **[1]** for identifying each factor and **[1]** for outlining how it enables increase in carrying capacity.*

(b) Explain how the growth in human population can affect local and regional water resources. **[7 max]**

growing human populations result in increased need for water for domestic/drinking/cooking use;
Commercial development/industrialisation/factories increase water demand;
increasing food demand entails increased irrigation/water for crops/agriculture;
increasing populations may increase poverty and thus economic water scarcity;
areas/locations/countries that have physical water scarcity would be mostly affected;
…causing freshwater land resources (lakes, rivers) to dwindle / risking sustainability of freshwater- resources / depletion of aquifers;
…often resulting in conflict over access to water;
increased groundwater abstraction may lead to intrusion from salt water;
(increased) industrial effluents can cause water (toxic) pollution;
dam construction to meet higher demands of growing population can affect sustainability of that water source;
increasing populations can stimulate technological innovation and greater efficiency of water use / management;

The points above may be credited through a case-study eg

case study: Egypt's population is growing fast, thus increasing demand for drinking water [1]. Need for more food in a country would increase need for irrigation [1] which would cause cause reduction in groundwater [1] in a country with scarce water resources (most water comes from the Nile river) [1]. Government has constructed dams in the Nile basin, which are threatening conflict between Egypt and its neighbouring countries [1] decreasing the amount of water downstream (due to evaporation) [1: different enough from groundwater/aquifer depletion] and decreasing silt which used to fertilize plains [1: an impact on water quality]. However more electricity is produced [no mark as IRRL] and provision of irrigation water is more stable/controlled (not dependent to seasonal floods) [1 for positive impact on water resources];

(c) To what extent would different environmental value systems be successful in reducing a society's ecological footprint? **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of ecological footprint; EVS; carrying capacity; sustainability; population growth;
- **breadth in addressing and linking** climate change; population growth; sustainability; food production methods; water resource management; SDW management; resource management; consumption rates; living standards; land use; environmental degradation;
- **examples** of different strategies/perspectives to reduce the EF of a society;
- **balanced analysis** discussing how the eco-, anthro-, and techno- centric EVSs would approach the reduction of a society's EF using a range of resource use and management and addressing a range of factors/variables influencing EF;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* ideologically, an ecocentric value system may be most successful in reducing ecological footprints but in practice there needs to be the legislative aspect of anthropocentrism and the technological innovation of technocentrism to be really effective*;*

Please see markbands on page 22.

7. (a) Outline **two** factors that affect the frequency and severity of photochemical smog in an area. **[4 max]**

societies with intensive fossil fuel use/industrialization;
...produce more of the primary pollutants;

high population density is characterized by car traffic/more dense use of heating;
...which increases the concentration of the primary pollutant;

local climate can have thermal inversions/lack of wind;
...that traps the smog/decreases its dispersion;

local climate with intense sunlight;
...increases photochemical reactions/increases rate of production of secondary pollutant;

topographic factors such as hills and mountains;
...can result in trapping the pollutants/reducing wind dispersion;

***Notes**: Award **[1]** max for clearly identifying each factor, and **[1]** max for outlining its effect on severity/ of smog:*
*Award **[1] max** if factors are simply identified by their title with no explanation* eg *"population density" and "topography"*
Any of the points above can be equally credited if presented in the form of a case study eg *Los Angeles / Mexico City, etc)*

(b) Evaluate strategies to manage regional acid deposition using the pollution management model. **[7 max]**

Altering human activity:
changing transportation use to reduce private transportation / increase public transportation / walking/biking;
- this can be expensive due to infrastructure improvements required;
- requires public buy-in / change in behaviour;
- successful if a reduction in use of fossil fuels for transportation needs;
- successful if good network of charging stations / footpaths/bike lanes to encourage change;
- addresses root cause of pollution/prevents any damage in first place;

education of public regarding value of renewable energies/impacts of pollution;
- this can influence more environmentally friendly choices;
- influences attitudes/values in future generations;
- but maybe the local governments/authorities that need influencing more than general public;

Controlling release of pollutant:
reduce sulphur content of fossil fuels using trading system or pollution budgets;
- has proved very successful in USA where government put legislation in place to support this;
- increases costs as low sulphur fuels are more expensive / requires technological investment;

use catalytic converters on car exhausts/scrubbers/CATS;
- very effective at reducing nitrous oxides;
- ...but expensive;
- use heavy metals which need to be mined;

catalysts need replacing frequently;
effective but requires investment in the technology and expensive;

switch to renewable energy sources/nuclear;
very effective as no direct emissions of NO_x or SO_x;
requires diversification of energy supply, which requires political will;
requires investment to support the change in energy policy;
successful when implemented with supportive legislation;

increase efficiency of power production and demand;
advantage that it reduces all pollutants associated with power production;

taxation systems and trading mechanisms;
very effective when implemented with political support;
requires improvement in public transportation infrastructure;
could be argued that not ethical as encourages trading of pollutants;

international legislation to control emissions (*eg* Sulphur Emissions Reduction Protocol and the Convention on Long Range Transboundary Air Pollution);
have been successful in reducing sulphur dioxide emissions;
...but led to increase in nitrous oxide production;
can be difficult to implement and monitor;

Clean-up and restoration of damaged systems:
adding limestone powder to acidified lakes;
effective and cheap solution;
but does not remove the cause of the problem;
environmental impact of mining the limestone;

restocking lakes after remediation;
needs careful management and unlikely to return the lake to the prior system;

reafforestation/replanting of damaged forests;
expensive;
takes long time for restoration;
new growth acts as effect carbon sink;

***Note**: Award **[5] max** if only one or two out of three levels of the pollution management model addressed.*
*Award **[3] max** if no evaluation points given.*

(c) To what extent have international agreements been successful in solving atmospheric air pollution and climate change? **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of international agreements (Montreal Protocol, Kyoto Protocol/Paris Agreement/UNCED/UNFCCC, Convention on LRTRAP, UNEP, UNECE, Agenda 21) in different environmental issues; climate change; air pollution; acid deposition; ozone depletion; solid domestic waste; resource depletion; population growth; energy choices;
- **breadth in addressing and linking** a wide range of international agreements with various solutions (laws/regulations/strategies/actions/projects) to issues of different forms of atmospheric pollution and climate change
- **examples** of international agreements; solutions to the problems requiring international agreements;
- **balanced analysis** discussing successful and less successful international agreements showing understanding of the factors involved in the amount of success;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* currently the Montreal Protocol is thought to be the most successful international piece of legislation tackling an environmental problem. The problem of ozone depletion was not challenged in the political sphere and there were solutions that industry could implement. It did not require any change to the way that people lived their lives. Climate change legislation, on the other hand has been politically controversial and despite all countries initially signing up to the Paris Accord in 2015, it is still struggling to be implemented as it requires system-wide changes to the way countries organise themselves;

Please see markbands on page 22.

Section B, part (c) markbands

Marks	Level descriptor
0	The response does not reach a standard described by the descriptors below and is not relevant to the question.
1–3	The response contains: • minimal evidence of knowledge and understanding of ESS issues or concepts • fragmented knowledge statements poorly linked to the context of the question • some appropriate use of ESS terminology • no examples where required, or examples with insufficient explanation/relevance • superficial analysis that amounts to no more than a list of facts/ideas • judgments/conclusions that are vague or not supported by evidence/argument.
4–6	The response contains: • some evidence of sound knowledge and understanding of ESS issues and concepts • knowledge statements effectively linked to the context of the question • largely appropriate use of ESS terminology • some use of relevant examples where required, but with limited explanation • clear analysis that shows a degree of balance • some clear judgments/conclusions, supported by limited evidence/arguments.
7–9	The response contains: • substantial evidence of sound knowledge and understanding of ESS issues and concepts • a wide breadth of knowledge statements effectively linked with each other, and to the context of the question • consistently appropriate and precise use of ESS terminology • effective use of pertinent, well-explained examples, where required, showing some originality • thorough, well-balanced, insightful analysis • explicit judgments/conclusions that are well-supported by evidence/arguments and that include some critical reflection.